The Stockholm Convention

Fiedler, Heidelore; Kallenborn, Roland; Boer, Jacob De; Sydnes, Leiv K.

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A Tool for the Global Regulation of Persistent Organic Pollutants

By Heidelore Fiedler, Roland Kallenborn, Jacob de Boer, and Leiv K. Sydnes

The aim of the Stockholm Convention on Persistent Organic Pollutants (POPs) is to eliminate persistent organic chemicals worldwide by either prohibiting their production and use or gradually reducing them. The Stockholm Convention was adopted in 2001 and entered into force in 2004, 90 days after receiving the 50th instrument of ratification. The Parties to the Convention have to regularly report progress in implementation of their measures taken to achieve the goals. The Convention has a mechanism to add more compounds; today 28 POPs are covered, 16 more than the initial ones.

The Stockholm Convention on POPs is a legally binding instrument for the protection of human health and the environment. Together with the Basel and Rotterdam Conventions, these three multi-lateral agreements are a unique framework for the life cycle management of hazardous chemicals and wastes. A "cradle-to-grave" approach is applied with interlinkages between their scopes of application:

- most POPs are covered by all three conventions;
- many pesticides are subject to the three conventions;
- as waste, all chemicals fall under the scope of the Basel Convention.

The three conventions are implemented by the Basel, Rotterdam and Stockholm Conventions (BRS) Secretariat, situated in Geneva, Switzerland, through (i) decisions by the Conference of the Parties (COPs); (ii) BRS-approved workplans; (iii) a resource-mobilization strategy; (iv) a communication strategy; and (v) a technical-assistance programme. Some facts about these conventions are summarized to the right.

History and Background

In 1995, the Governing Council of the United Nations Environment Programme (UNEP, now UN Environment) called for a global action on an initial list of 12 POPs. It was also requested that the Intergovernmental Forum on Chemical Safety (IFCS) should develop recommendations on international action for consideration no later than 1997 (www.pops.int). IFCS found that the scientific information on these POPs was sufficient to conclude that immediate international action was needed to protect human health and the environment. These conclusions and recommendations were approved by the UNEP Governing Council (GC) and the World Health Assembly and it was decided to begin negotiations of a global legally binding instrument by early 1998 within the framework of overarching objectives that were to be handled by an intergovernmental negotiating committee (INC) (Buccini, 2003). Over 120 countries participated in the negotiation

Basel Convention on the Control of Transboundary Movement of Hazardous Wastes and Their Disposal

Number of Signatories: 53

Number of Parties: 186

Date of adoption:
22 Mar 1989

Date of entry into force:
5 May 1992

Rotterdam Convention on Prior Informed Consent Procedures for Certain Hazardous Chemicals and Pesticides in I nternational Trade

Number of Signatories: 72

Number of Parties: 160

Date of adoption:
10 Sep 1998

Date of entry into force:
24 Feb 2004

Stockholm Convention on Persistent Organic Pollutants

Number of Signatories: 152

Number of Parties: 182

Date of adoption:
22 May 2001

Date of entry into force:
17 May 2004

meetings until the final text was agreed upon. In May 2001 the final document, *The Stockholm Convention on Persistent Organic Pollutants*, was adopted and opened for signature in Stockholm, Sweden, and as of August 2018, there are 182 parties to the Convention, 181 states and the European Union, which adopted the Convention to EU legislation already in 2004. Among the countries that have not ratified the Stockholm Convention are Israel, Italy, Malaysia, and the United States of America (USA).

The objective of the Stockholm Convention is defined in article 1: "*Mindful of the precautionary approach, to protect human health and the environment from the harmful impacts of persistent organic pollutants.*" POPs are defined as chemicals that

- remain intact for exceptionally long periods of time (many years);
- become widely distributed throughout the environment as a result of natural processes involving soil, water and, most notably, air (mobility; long-range transport);
- accumulate in the fatty tissue of living organisms including humans, and are found at higher concentrations at higher levels in the food chain; and
- are toxic to both humans and wildlife.

In addition to being clearly identified (subparagraph (a) below), POPs have to fulfill a number of specific criteria as outlined in Annex D "Information requirements and screenings criteria":

(a) Chemical identity:

(i) Names, including trade name or names, commercial name or names and synonyms, Chemical Abstracts Service (CAS) Registry number, International Union of Pure and Applied Chemistry (IUPAC) name; and

(ii) Structure, including specification of isomers, where applicable, and the structure of the chemical class;

(b) Persistence:

(i) Evidence that the half-life of the chemical in water is greater than two months, or that its half-life in soil is greater than six months, or that its half-life in sediment is greater than six months; or

(ii) Evidence that the chemical is otherwise sufficiently persistent to justify its consideration within the scope of this Convention;

(c) Bio-accumulation:

(i) Evidence that the bio-concentration factor or the bio-accumulation factor in aquatic species for the chemical is greater than 5000, or in the absence of such data, that the log K_{OW} is greater than 5;

(ii) Evidence that a chemical presents other reasons for concern such as high bio-accumulation in other species, high toxicity or ecotoxicity; or

(iii) Monitoring data in biota indicating that the bio-accumulation potential of the chemical is sufficient to justify its consideration within the scope of the Stockholm Convention;

(d) Potential for long range transport:

(i) Measured levels of the chemical in locations distant from the sources of its release that are of potential concern;

(ii) Monitoring data showing that long-range environmental transport of the chemical, with the potential for transfer to a receiving environment, may have occurred *via* air, water or migratory species; or

(iii) Environmental fate properties and/or model results that demonstrate that the chemical has a potential for long-range environmental transport through air, water or migratory species, with the potential for transfer to a receiving environment in locations distant from the sources of its release. For a chemical that migrates significantly through the air, its half-life in air should be greater than two days; and

(e) Adverse effects:

(i) Evidence of adverse effects to human health or to the environment that justifies consideration of the chemical within the scope of this Convention; or

(ii) Toxicity or ecotoxicity data that indicate the potential for damage to human health or to the environment.

The POPs are listed in one or more of three annexes with different obligations; Annex A for elimination of production and use, Annex B for restriction of production and use, and Annex C for unintentionally generated and released substances. How the elimination and restriction are going to be carried out is described administratively and technologically (Articles 3 – 6, 11 and 12). The detailed implementation is up to the Parties to plan, present, update and execute (Article 7); specific actions are to be reported through Article 15.

The Stockholm Convention has proven to be a dynamic document and since 2009, 16 more POPs have been added. Whereas the 12 initial POPs were all chlorinated chemicals and had direct uses such as pesticides or industrial chemicals, many of the more recent POPs are integrated into articles or products such as flame retardants and water repellent chemicals.

The POPs presently listed in the Stockholm Convention are displayed in Table 1.

Chemicals in Annexes A and B

For the initial 12 POPs, all production and new uses ended in 2009, but time-limited exemptions exist for many of the newly listed POPs such as HBCD, PCP, PCNs, lindane, technical endosulfan and polybrominated diphenyl ethers. The register is publicly available (http://chm.pops.int/Implementation/Exemptions/SpecificExemptions/ChemicalslistedinAnnexA/tabid/4643/Default.aspx). PCB can remain in existing applications such as transformers or capacitors until 2025 for all Parties.

For the two POPs listed in annex B—DDT and PFOS—there are not yet safe and affordable alternatives available and therefore, they can still be produced or used for acceptable purposes. For DDT, the acceptable purpose is disease vector control but parties are required to notify the Secretariat of such production or use or the intention to do so. The Secretariat maintains a DDT Register which presently has 17 countries listed (Botswana, Eritrea, Ethiopia, India, Madagascar, Marshall Islands, Mauritius, Mozambique, Namibia, Senegal, South Africa, Swaziland, Uganda, Venezuela, Yemen, Zambia, Zimbabwe). Parties may withdraw from

Table 1: (at right) The chemicals targeted by the Stockholm Convention, including the 12 initial and 16 new POPs as listed in Annexes A (Elimination), B (Restriction) or C (Unintentional production), and their year of listing. Three types of chemicals as pesticide (green dot), industrial chemical orange triangle, or unintentional production (purple square) are identified.

POPs and their year of listing into the Convention:

Annex A (Elimination)

Initial POPs: Aldrin ●
Chlordane ●
Dieldrin ●
Endrin ●
Heptachlor ●
Hexachlorobenzene (HCB) ● ▲
Mirex ●
Polychlorinated biphenyls (PCB) ▲
Toxaphene ●

2009: Alpha hexachlorocyclohexane (α-HCH) ●
Beta hexachlorocyclohexane (β-HCH) ●
Chlordecone ●
Hexabromobiphenyl ▲
Hexabromodiphenyl ether and heptabromodiphenyl ether ▲
Lindane (γ-HCH) ●
Pentachlorobenzene (PeCB) ● ▲
Tetrabromodiphenyl ether and pentabromodiphenyl ether ▲

2011: Technical endosulfan and its related isomers ●

2013: Hexabromocyclododecane (HBCD) ▲

2015: Hexachlorobutadiene (HCBD) ▲
Pentachlorophenol (PCP) and its salts and esters ●
Polychlorinated naphthalenes (PCNs) ▲

2017: Decabromodiphenyl ether (commercial mixture c-decaBDE) ▲
Short-chain chlorinated paraffins (SCCPs) ▲

Annex B (Restriction)

Initial POP: DDT ●

2009: Perfluorooctane sulfonic acid (PFOS), its salts and perfluorooctane sulfonyl fluoride (PFOSF) ● ▲

Annex C (Unintentional Production)

Initial POPs: Polychlorinated dibenzo-*p*-dioxins (PCDD) ■
Polychlorinated dibenzofurans (PCDF) ■
Hexachlorobenzene (HCB) ■
Polychlorinated biphenyls (PCB) ■

2009: Pentachlorobenzene (PeCB) ■

2015: Polychlorinated naphthalenes (di- through octa; PCNs) ■

2017: Hexachlorobutadiene (HCBD) ■

● Pesticide
▲ Industrial Chemical
■ Unintentional Production

Country	Year Start of production	Year End of production	Quantity (1 000 tonnes)
India	1955	Ongoing	239
Dem. People´s Rep. Korea	1960	> 2010?	21
China	1952	2007	467
Mexico	1959	2004	> 93
Bangladesh	1966	1992	8
Indonesia	1986	1991	23
Brazil	1962	1982	76
Azerbaijan	1958	1980	481
Poland	1947	1980	79
United States of America	1944	1973	1383
Serbia	1947	1960	2
Total			**2793**

Table 2: Start, end, and total quantity of production of DDT by country.

the DDT register at any time, which three countries have done so far, namely People's Republic of China, Morocco, and Myanmar.

In an attempt to summarize production and use of DDT, the Chemicals Branch of the United Nations Environment Programme (UNEP) in collaboration with partners, has compiled available information regarding historic production and use (Table 2: Start, end, and total quantity of production of DDT by country.).

For PFOS, a list of acceptable purposes has been established; this includes photoimaging, aviation fluids, metal plating in closed loop systems, fire-fighting foams, and for control of leaf-cutting ants (http://chm.pops.int/Implementation/Exemptions/AcceptablePurposes/tabid/793/Default.aspx).

PCBs have received special attention for years. The Convention requires the parties to eliminate the use of PCB in equipment by 2025 and make determined efforts to environmentally-sound waste management by 2028. Reports on progress towards their elimination should have been provided every five years but information is scarce. In order to keep track of the situation, an inventory of historic PCB production has been developed (Table 3: Estimated total global production of PCB according to country and period.), and the progress towards the elimination of PCBs according to the 2025 and 2028 goals is under evaluation.

Chemicals in Annex C

Chemicals in Annex C are formed and released unintentionally during the production of other compounds or in thermal processes. To prevent formation of these POPs and reduce their unintentional releases, Parties shall develop release inventories, apply best available techniques (BAT) and promote best environmental practices (BEP) and report progress every five years. Among the POPs listed in Annex C, the polychlorinated dibenzo-*p*-dioxins (PCDD) and dibenzofurans (PCDF) are the only ones that are exclusively listed in this annex and therefore serve as a model for the other POPs listed in the same annex. A guidance document has been prepared describing how to identify and quantify formation and release to five vectors—air, water, land, products, residues—that allows the development of complete and comparable inventories. Periodically, the inventories have been assessed and the latest assessments were published in 2016 (Fiedler, 2016; Wang *et al.,* 2016). Based on 86 national release inventories and other data, the global release of PCDD and PCDF

Country	Start of production (year)		End of production (year)		Amount of PCB produced (1000 t)	
	Earliest estimate	Latest estimate	Earliest estimate	Latest estimate	Lowest estimate	Highest estimate
China	1960	1965	1974	1983	7	10
Czechoslovakia	1959	1959	1984	1984	21	21
Democratic People's Republic of Korea	1960s	1960s	2006	> 2006	25	30
France	1930	1930	1980	1984	102	135
Italy	1958	1958	1983	1983	24	31
Japan	1952	1954	1972	1972	59	59
Poland	1966	1966	1977	1977	2	2
Soviet Union/ Russian Federation	1938	1939	1993	1993	180	180
Spain	1930	1955	1984	1986	25	29
United Kingdom	1951	1954	1965	1977	66	67
United States of America	1929	1930	1975	1977	476	700
West Germany	1930	1950	1983	1983	59	300
Total					1046	1512

Table 3: *Estimated total global production of PCB according to country and period.*

was estimated to be approximately 100 kg toxic equivalents *per* year (g TEQ/yr) (Table 4: Global estimate of PCDD/PCDF releases (TEQ per year)).

Stockpiles and wastes

According to the Convention, Parties shall manage stockpiles and wastes containing listed chemicals in a manner protective of human health and the environment. POPs in wastes are not allowed to be reused or recycled. In close cooperation with the parties to the Basel Convention, the maximum POPs content has been defined, for single POPs pesticides and PCB at 50 mg/kg and for new POPs that are incorporated into articles around 1000 mg/kg, and 15 µg TEQ/kg for PCDD and/or PCDF. Concentrations above these levels, waste consisting of, containing or contaminated with the listed POPs have to be treated using recommended destruction technologies.

Effectiveness evaluation and global monitoring plan

A mechanism to assess the success of the activities undertaken worldwide to implement the Stockholm Convention is laid down in Article 16. These assessments are based on comparative analytical data on concentrations of POPs, national reports from the 182 Parties to the Convention (Article 15), and non-compliance information provided pursuant to established procedures (Article 17). To date, the Conference of the Parties could not agree on a compliance mechanism (according to Article 17). Presently, information gathering is underway for the fourth collection of national reports. Hopefully, the submission of the reports will be better than in the past; in 2007, 2011 and 2014 the numbers were as low as 45, 95 and 93, respectively (for overview and update, see http://chm.pops.int/Countries/Reporting/ReportingDatabase/tabid/7477/).

As to new POPs, parties have the possibility to opt out; *i.e.* not to ratify the listing of new POPs. (http://chm.pops.int/Countries/StatusofRatifications/Amendmentstoannexes/tabid/3486/). With 182 parties at present, none of the new POPs is legally binding for all Parties. For example, Australia, India, Slovenia, and Vanuatu have not accepted any of the new POPs.

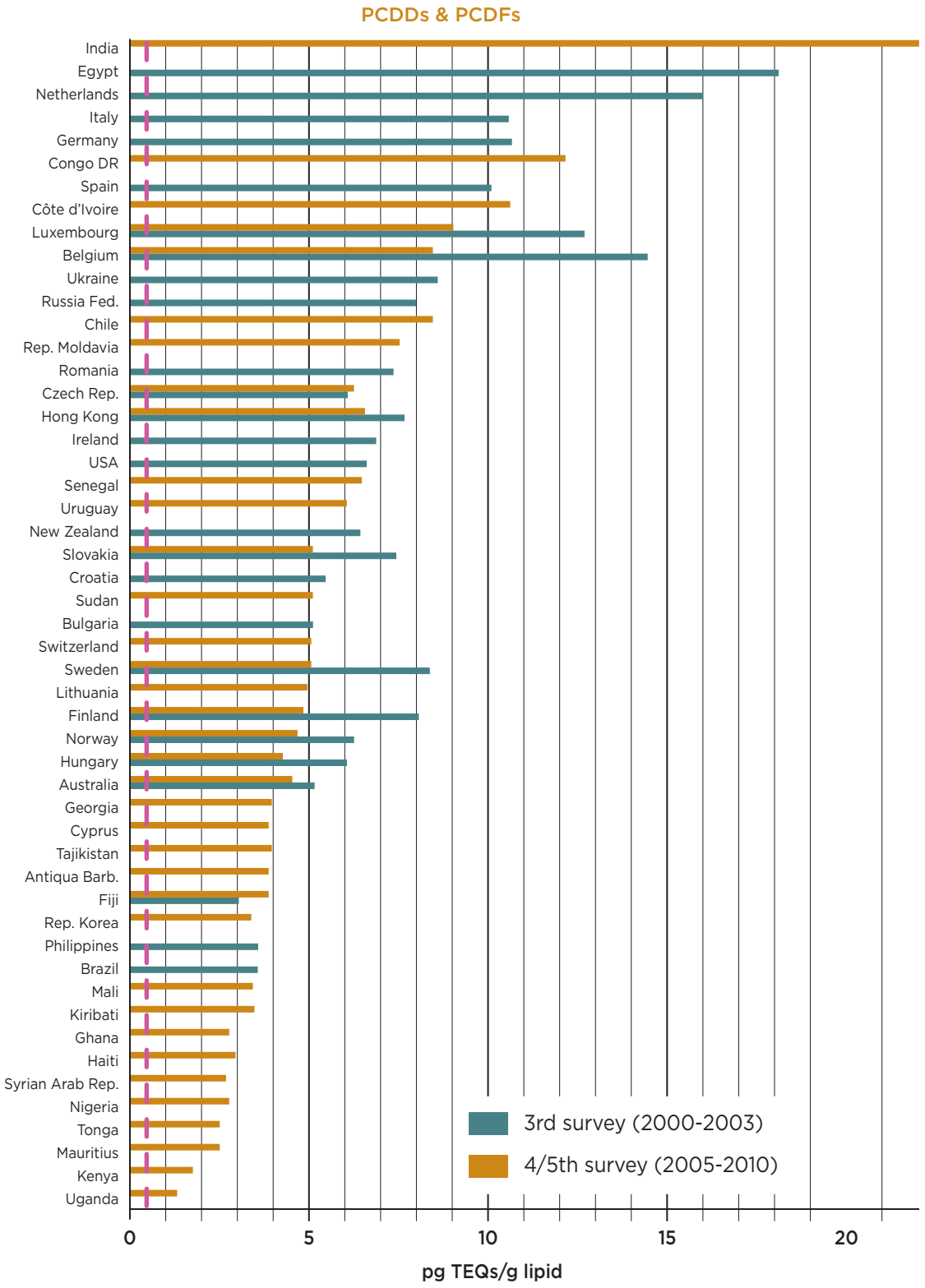

Figure 1. *Results of the WHO/UNEP survey of PCDD and PCDF (pg TEQ/g lipid) in pooled human milk samples from selected countries. The dotted pink line represents the calculated safe level of these compounds for the breastfed infant. (Source: van der Berg et al., 2017, reproduced with permission) (That source (www.doi.org/10.1007/s00204-016-1802-z) includes similar results representation for DL-PCBs, for the sum of the indicator PCBs, and for the sum of DDT-like compounds)*

Region	Number of countries	Total (g TEQ/yr)	Area averaged (mg TEQ km^{-2})	Population averaged (mg TEQ $person^{-1}$)
Africa	52	29 596	0.98	34.2
Asia	58	47 101	0.98	12.1
Europe	44	9682	1.36	14.8
Oceania	2	1861	0.23	79.9
North America	26	43 341	0.19	8.79
South America	14	7851	0.45	11.1
All	196	100 424	0.75	16

Table 4: ***Global estimate of PCDD/PCDF releases (TEQ per year)***

To assess changes of POP concentrations in the environment or in humans, a Global Monitoring Plan (GMP) for POPs has been set up. The GMP includes training of POP laboratories in developing countries and interlaboratory assessments on POPs with the aim that all laboratories that provide results to the GMP have successfully participated in these assessments. As core matrices, ambient air and human tissues (human milk or human blood) have been chosen for all POPs, and in addition, surface water for the hydrophilic chemicals (presently, only PFOS). Guidelines for sampling and analysis of the POPs have been established and are updated as more POPs are listed. The monitoring data presently addresses 23 of the 28 POPs and are broadly shared through the GMP data warehouse (http://www.pops-gmp.org/). Especially, the human milk monitoring activities—jointly performed with the World health Organization (WHO)—have provided harmonized and comparable data of high quality, and these data are very useful when the impact of POPs on human health is being addressed. The results from monitoring of PCDD and PCDF (Figure 1) show for instance that their concentrations in human milk are still significantly above that considered toxicologically safe in all countries. On the other hand, the numerically highest concentrations for the sum of DDTs pose a lower risk for breastfed babies (van den Berg *et al.*, 2017). (When balancing potential adverse effects against positive health aspects for (breastfed) infants, the advantages of breastfeeding outweigh the possible disadvantages).

Financial Mechanism

In contrast to the Basel and Rotterdam Conventions, the Stockholm Convention has a financial mechanism, the Global Environment Facility (GEF), to help developing countries and countries with economies in transition to meet their convention obligations. Since the adoption of the Convention over 4 billion USD in financial support has been granted.

Conclusions and Future

The Stockholm Convention has initiated many activities in the field of POP monitoring. Not only do countries contribute to the GMP, also third parties such as universities and research institutes have become more focused on POP research. The true effect of the Stockholm Convention is therefore much bigger than initially anticipated. Also, the capacity building part is very much welcomed by the developing countries and even reaches further than only POP analysis. On the other hand, still much has to be done to achieve the original goals of eliminating the production and use of POPs and gradually reduce spreading into the environment and causing harm to humans. A global treaty with so many countries involved is in a continuous challenge with procedures and political realities in countries, which hamper the achievement of perceived simple goals such as eliminating the use of PCB in 2025.

Nevertheless, the Stockholm Convention moves forward and in May 2019, two more POPs may be listed: the POPs Review Committee in September 2018 recommended to the Conference of the Parties that it consider listing dicofol in Annex A to the Convention without specific exemptions. Furthermore, the Committee recommended listing pentadecafluorooctanoic acid (PFOA), its salts and PFOA-related compounds in Annex A or B to the Convention with specific exemptions.

Heidelore Fiedler <Heidelore.fiedler@oru.se> is a professor of chemistry at Örebro University and German representative in groups of experts under the Stockholm Convention, and consultant for the Basel Convention. She is a former senior scientific affairs officer of the United Nations Environment Programme (UNEP)

Roland Kallenborn <roland.kallenborn@nmbu.no> is professor of organic analytical chemistry at the Norwegian University of Life Sciences, Norway. He is Norwegian delegate to the Division of Chemistry in the Environment (DCE) in the European Association for Chemical and Molecular Sciences (EuCheMS).

Jacob de Boer <jacob.de.boer@vu.nl> is a professor of environmental chemistry and toxicology at the Vrije Universiteit in Amsterdam, the Netherlands and for many years has served as advisor to UN Environment on capacity building.

Leiv K. Sydnes <leiv.sydnes@uib.no> is professor emeritus at University of Bergen, Norway. He was president of IUPAC 2004–2005 and chaired the CHEMRAWN committee from 2008–2015.

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